BELL TELEPHONE QUARTERLY

SINGLE COPY ~ 50¢ ~

PER YEAR ~ $1.50 ~

JANUARY, 1927

TABLE OF CONTENTS

New York-London Telephone Service is Opened

1926-1927: An Economic Review and Outlook
F. E. Richter

Outwitting the Weather
F. L. Rhodes

Quality of Telephone Materials
R. L. Jones

Some Distinguishing Characteristics of the Telephone Business
R. S. Coe

Bust of Dr. Bell is Presented to Smithsonian Institution

Abstracts of Recent Technical Papers from Bell System Sources

Notes on Recent Occurrences

Organization Changes

AMERICAN TELEPHONE & TELEGRAPH CO.
NEW YORK

Opening of New York-London Telephone Service, January 7, 1927, by Mr. Walter S. Gifford, President of the American Telephone and Telegraph Company

BELL TELEPHONE QUARTERLY

A MEDIUM OF SUGGESTION
AND A RECORD OF PROGRESS

Published quarterly for the Bell System by the American Telephone and Telegraph Company

Subscription, $1.50 per year, in United States and Canada; single copies, 50 cents

Address all communications to
INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

Vol. VI JANUARY, 1927 No. 1

New York-London Telephone Service Is Opened

COMMERCIAL telephone service between New York and London, for years a goal of telephone scientists and engineers, became a reality on January 7th when, after an exchange of greetings between President Walter S. Gifford of the American Telephone and Telegraph Company, and Sir G. Evelyn P. Murray, Secretary of the General Post Office of Great Britain, the line was declared in the public service.

Announcements had been made both in New York and in London that applications for the use of the circuit would be received beginning Wednesday, January 5th, at 8:30 A.M. and that the order in which the applications were received would determine the assignment of the circuit after its formal opening. The announced rate was $75 for three minutes.

The keen interest manifested in the service on both sides of the Atlantic was evidenced by the number of calls booked for the opening day, and when the circuit was closed down, a total of 31 trans-oceanic calls had

been handled including messages between banks, newspapers, business concerns and individuals. Transactions in foreign exchange were conducted, advertisements were telephoned, the Mayors of the world's two largest cities conversed, and in many other ways the economic and social value of long distance telephone transmission across the Atlantic was illustrated.

The New York ceremonies in connection with the opening of the service took place in the directors' room of the American Company's headquarters at 195 Broadway.

Mr. Gifford's Preliminary Address

To the directors and officers of the Company who had been invited to attend the ceremonies, Mr. Gifford outlined the continuous research and experimentation that had brought to pass the realization of trans-Atlantic telephony, in the following preliminary address:

"Today we are now giving formal recognition to an achievement which has been long in the making. We can build in thought more rapidly than we can with the materials that nature has put at our disposal. It was twenty-two years ago that our engineers applied the first telephone amplifier, technically known as a repeater, as an experiment in one of the lines between New York and Chicago. The effect was equivalent to shortening that line by 300 miles. The repeater was successful in renewing the telephonic voice, and from that and other developments has grown a continental network of telephone wires on the one hand, uniting our forty-eight States, Canada, and Cuba, and on the other the transatlantic telephone link over which we will presently speak with London, and which, we hope in the near future will unite all of our telephones with all of those of Great Britain.

"After the successful trial, twenty-two years ago, of that early telephone amplifier, our engineers declared:

'We now know that some day we shall be able to talk across the greatest distances, whether over land or over water.'

Between the winning of the scientific knowledge of the forces of nature from which to predict that a given result can be accomplished and the perfection of physical instrumentalities through which we may enrich our daily lives, there lies a gap which usually requires years of well-directed effort to span. To shorten this interval the American Telephone and Telegraph Company maintains a large research laboratory and a skilled engineering staff. That even with these tools of modern industry, the journey from that early repeater to today's achievement should have required so many years testifies to the difficult character of the problem.

"I will mention briefly a few of the more important stages of that journey. Ten years after the installation of the first repeater in the New York-Chicago line, our first transcontinental line was opened for public use. Following this we undertook experiments in the field of radio telephony, and within a few months our engineers had designed and built radio telephone equipment which enabled them to transmit the voice across the Atlantic to Paris and across our own continent and out into the Pacific as far as Hawaii.

"There are certain aspects of that important experiment of 1915 that I should like to mention. For one thing, we had to borrow an antenna which would be large enough to transmit over the long distances we hoped to attain. One of the few such antennas on the Atlantic Coast was that at Arlington, Va., belonging to the Navy and the use of that antenna was generously granted.

"At Paris, in spite of the war, permission was also generously granted for our engineers to equip the Eifel Tower with our radio telephone receiving apparatus. The ten minute period immediately following 2:00 A.M. which the French assigned us was favorable so far as atmospheric conditions were concerned, but interference

from high-powered telegraph stations throughout Europe presented an almost impenetrable barrier to our faint speech signals coming from Arlington. After weeks of fruitless listening, success came at last. One night, just as they were ceasing their efforts, our engineers in Paris caught the words 'and now, Shreeve, good-night.' There was no mistaking the origin of those words, and within a few minutes a cablegram was on its way to New York, telling of the success. On following evenings, reception proved better and was heard with as much gratification by the French engineers invited to be present as by our own. Although 1500 miles farther away, Honolulu had picked up our messages from Arlington much sooner than Paris because of better receiving conditions.

"Following the close of the World War, experimentation was again begun and new lines of development were undertaken, with the result that many notable improvements were perfected. Time does not permit an enumeration of these, but to illustrate the kind of thing that was done I will mention a new water-cooled vacuum tube which to the eye is very little larger than the tube used in 1915, but which is about 400 times as powerful. The 'single side band' type of transmission, which was also developed then, utilizes the power of the apparatus some five times as efficiently; and our developments in methods of receiving signals further improved transmission. To summarize, we are today employing about 100 times the power that our apparatus of 1915 could handle, and utilizing this power to many times as good advantage.

"The effectiveness of these developments was first illustrated publicly in a test of January, 1923, during which officials of our company speaking in New York, were, by pre-arrangement, heard in London by a large gathering of engineers and scientists. The test continued for some four hours, and frequent cable replies stated that as different speakers came to our microphone

not only their words, but their voices as well were recognized by the listeners.

"That test involved only one-way transmission, but its success indicated that satisfactory, although perhaps limited, two-way talking could be carried out when apparatus to provide a return radio circuit was installed. This the British Post Office has since done. Their transmitting station is located at Rugby which constitutes the hub of their imperial radio telegraph system. The completion of their part of the two-way telephone system was signalized by tests made last March at which representatives of the New York and London Press conversed together throughout one Sunday forenoon. Months of continuous testing have followed this test, during which the engineers of our two institutions have been in close cooperation, and have prepared the way for the formal opening for commercial service this morning.

"For a number of years past, our engineers have been experimenting with long distance telephony using very short wave lengths. These experiments, as carried out across the Atlantic, indicate a lesser degree of reliability for short wave transmission than for long, but have brought to light the fact that short wave transmission is often successful at times when the long wave is subject to the greatest disturbances. Today our engineers are providing the novel arrangement of simultaneous transmission eastward on long waves of 5000 meters and short waves of 22 meters. These are both available to the receiving operator in London who chooses which ever gives the better reception. Our short wave transmission is directive such as is sometimes called 'beam' transmission.

"Even with these alternate wave transmissions, however, the natural disturbances to which radio transmission is subject are sometimes too great for us. We cannot as yet guarantee a good talking connection with London all of the time. When atmospheric conditions are very bad, it is utterly impossible to carry on a con-

versation. We cannot claim, therefore, that the problem of trans-oceanic telephony is entirely solved; but our efforts have reached such a stage that we believe progress can now most rapidly be made by having commercial use and further research studies go on together. By careful observation of the extent to which our present facilities are able to meet the demands of public service, we shall gather the data necessary to bettering the facilities.

"Today, we dedicate the first of a new type of telephone trunk line, good over those wide spans of water across which we have not as yet learned to string wires."

Transatlantic Telephone Service Officially Opened

At the conclusion of this address Mr. Gifford lifted the receiver of an ordinary desk-set and with the guests listening through receivers especially installed at each chair, asked for a telephone connection with Sir G. Evelyn P. Murray. The call was completed in less than a minute and the historic conversation, over a circuit of wire and ether 7,190 miles in length between Bell System headquarters and the British General Postoffice, began. Mr. Gifford's greeting was as follows:

"Today, as a result of very many years of research and experimentation, we open a telephonic channel of speech between New York and London. Thus, the people of these two great cities will be brought within speaking distance. Across three thousand miles of ocean, individuals in the two cities may, by telephone, exchange views and transact business instantly as though they were face to face. I know that it is your aim, as it is ours, to extend this service so that in the near future any one in either of our countries may talk to any one in the other.

"No one can foresee the ultimate significance of this latest achievement of science and organization. It will certainly facilitate business; it will be a social convenience and comfort; and, through the closer bond which it

establishes, it will promote better understanding and strengthen the ties of friendship. Through the spoken word, aided by the personality of the voice, the people of New York and the people of London will become neighbors in a real sense, although separated by thousands of miles.

"We are glad to have cooperated with you in this notable enterprise and shall actively continue to work with you in extending and improving the service. I congratulate you upon your successful solution of your problems and wish to extend to you and to your associates the greetings and good wishes of the officers and staff of the American Telephone and Telegraph Company and of their associates in the Bell Telephone System."

SIR EVELYN MURRAY'S REPLY TO MR. GIFFORD

The reply of Sir Evelyn Murray, at the British General Post Office, to Mr. Gifford, at Bell System headquarters in New York, was as follows:

"The opening of a public telephone service across the Atlantic between London and New York is a conspicuous milestone on the road of telephone progress and marks the beginning of a new epoch in the development of communication between our two countries. Personal conversation between Great Britain and the United States has emerged from the stage of experiment into a practical reality, and we are confident that the service, which we are inaugurating today will be a boon to both nations, whether as an aid to commerce or as a medium of social and domestic intercourse and will tend to strengthen the bonds which unite the two communities.

"I am charged by the Postmaster General to take this occasion to acknowledge the notable contributions which your company has been able to make through its engineering and research organization, towards the solution of the many baffling problems which have been encountered. We recognize, as we believe you recognize, that there are difficulties still to be overcome before the

transatlantic service can attain the standard of regularity and reliability at which we aim, but we are convinced that there is no better means of solving these difficulties than by putting the service to the crucial test of daily use, and we hope that before long transatlantic conversation will be available not only to the citizens of London and New York but to every telephone subscriber in both countries.

"We of the British Post Office look back with pleasure upon the cordial cooperation with the American Telephone and Telegraph Company, which has led to the success so far achieved, and on behalf of the Postmaster General and the officers of the General Post Office I warmly reciprocate your greeting and good wishes. I now declare the service opened to the public."

1926-1927:
An Economic Review and Outlook

IN an article similar to this one, written a year ago for this QUARTERLY, it was said in conclusion that "the year 1926 will hardly go out with as rosy an outlook as has the year 1925, but it seems probable that in retrospect it will be thought of as, on the whole, a year of good business conditions." The events of the year just closing present a picture which tallies reasonably well with that conclusion. Like 1925, the year 1926 has witnessed exceedingly active business and well distributed prosperity. Unlike 1925, or practically any other year in our history, 1926 has been characterized by an exceptional degree of stability of business operations, especially considering the high level of business activity.

It will be recalled that the second half of 1925 was notable for an outburst of activity in the automobile and construction industries, which was naturally passed on to the iron and steel and other industries which provide materials for vehicles and buildings. The result was that in the last quarter of the year a much more than seasonal increase in the volume of general business took place, activity reaching a peak in December at a very high level above what might be called a normal rate. During the first quarter of the new year, there was a slight falling off from this level, though the recession was not cumulative, partly because some industries did not curtail operations to a sufficient degree and, as a result, piled up some rather burdensome inventories. Further recession, though again of a very mild character, then occurred in the second quarter of the year. Stabilization again promptly followed, so that by the end of the summer, business felt itself again in a position to increase more than seasonally the scale of operations into the fourth quarter of the year. Neither

the recession during the first half of the year nor the upturn in the second was of the same dimensions as in 1925, to say nothing of the sharp and relatively violent fluctuations in 1924. At the close of 1926 another gradual slight recession in activity was in progress.

The combination of a high general level of business activity and comparative freedom from fluctuations in that level brought it about that 1926 established more than its share of new high records. Among these records, certain or probable, may be cited the following: output of motor vehicles, volume of building construction contracts awarded, production of steel ingots, total volume of railroad freight traffic handled, volume of check payments, output of crude petroleum and consumption of gasoline, production of cement, volume of imports, volume of corporate financing, sales of life insurance, prices of industrial stocks; and last but not least, though, of course, not directly related to industrial activity, the production of an enormous cotton crop estimated at more than 18,000,000 bales. Numerous other statistical records were broken, even in industries which, unlike our own, do not show uninterrupted growth, in fair weather and foul, and doubtless a great many other new high records were made for which statistics, either past or present, are not available for comparative purposes, as, for example, in total retail trade. The foregoing list, even allowing for the circumstance that the factor of growth should make for new records in many lines of business, is impressive enough, partly because of its heterogeneity. It is almost unnecessary to add that practically throughout the year labor in almost all sections of the country and in almost all industries was fully employed. Labor turnover was apparently quite as low as in 1925 and shortages of labor hardly existed except in isolated instances and for certain types of skilled labor.

PRICES; AGRICULTURE

Shortages of goods, save for anthracite coal last winter, during the strike, and bituminous coal for a few weeks this past fall, similarly did not exist. Price stability for industrial commodities, though with a slight downward tendency, therefore accompanied and reflected stability in industrial operations. Prices of agricultural commodities were sagging most of the year, and in the early autumn occurred a precipitate fall in the price of raw cotton. By the close of the year, most of the ground that had been gained in the 15 months beginning June, 1924, toward adjusting agricultural and non-agricultural prices to a pre-war relationship, had been lost.

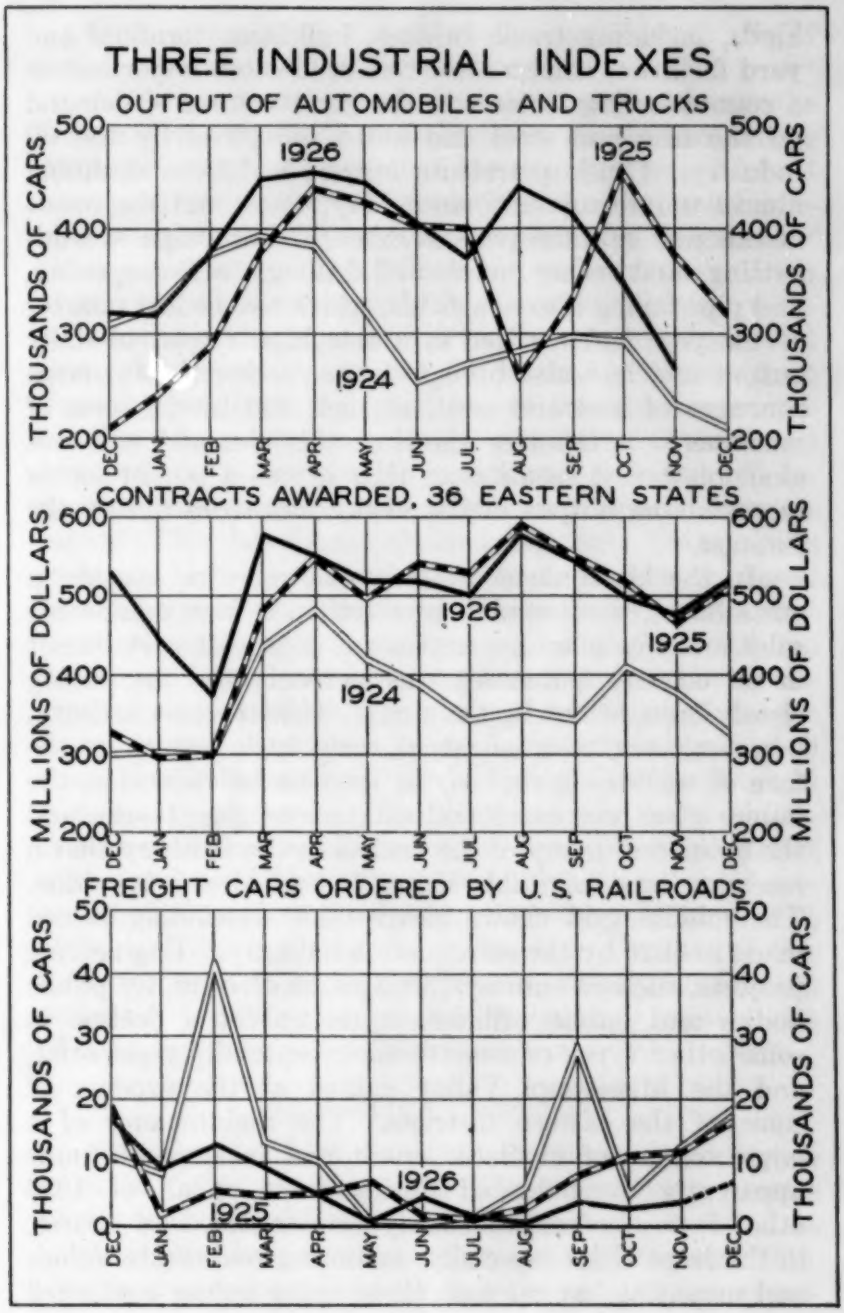
The fact that agricultural prices declined through 1926 does not, however, mean that the agricultural industry was depressed or the agricultural classes lacking in purchasing power. The preceding year had benefitted from the good financial results of 1924 harvests, and the relatively high prices received for 1925 crops and livestock were reflected in large sales to farmers in 1926 by mail order houses and very substantial expenditures by farmers for harvesting machinery and other equipment, and for automobiles. Toward the end of the year, to be sure, the combination of a small spring wheat crop in the Northwest, minor crop failures there, very low corn prices, together with a small corn crop and a somewhat depleted swine population in the corn belt, reduced incomes for dairy and poultry farmers, and the lowest cotton prices since 1921, were beginning to make themselves felt both in expenditures for current consumers' needs and in plans for purchases of equipment and fertilizer over the next twelve months.

Agricultural well-being and purchasing power, relatively easy money, record activity by the automobile and building industries, and generally sound financial, industrial and labor conditions, were the four corners of the foundation laid for 1926 business by its immedi-

ate predecessor. If these could hold all year, industry, soundly supported, would perforce continue active, employment steady, wages high and prosperity general among all classes of the population. And it was because many felt that, whatever developed in agriculture and in finance, the automobile and building industries could not continue at their 1925 rates of activity, that they were looking for business to show by the mid-year definite signs of recession. Agricultural income for the country as a whole is lower for the crop year 1926–27 than for 1925–26, though such effects as are felt will not all be immediately observable, and at worst should be of minor scope except in certain localities. Of the financial situation more will be said later. Let us consider for the moment the contributions made to the year's business history by four industries: automobiles, building, railroads, and oil.

Four Important Factors

The chart on page 13 gives the monthly record for the years 1924, 1925, and 1926, of three industrial indexes: production of motor vehicles in the United States and Canada; the awards of contracts for construction in 36 Eastern States, as compiled by the F. W. Dodge Corporation; and the orders for freight cars placed by railroads of the United States. In each case the figures are actual, without any correction for seasonal or other influences. In the case of all three factors, 1926 started off with a good margin, month by month, over 1925; and in the case of building contracts, over 1924 also. The margin soon narrowed—in varying degrees in the three cases—but even though the spring or summer brought dips in all three 1926 curves below the 1925 curves, there was only in the case of the freight car curve an important recession from the first quarter levels. The unexpectedly small volume of railroad equipment buying was fully counteracted by substantial railroad expenditures on construction work of various


THREE INDUSTRIAL INDEXES
OUTPUT OF AUTOMOBILES AND TRUCKS
THOUSANDS OF CARS
500
400
300
200
1926
1925
1924
DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
CONTRACTS AWARDED, 36 EASTERN STATES
MILLIONS OF DOLLARS
600
500
400
300
200
1926
1925
1924
FREIGHT CARS ORDERED BY U. S. RAILROADS
THOUSANDS OF CARS
50
40
30
20
10
0
1926
1925

kinds, including track, bridges, buildings, terminal and yard facilities, and so on. But even more important as a countervailing factor was the great volume of demand on the iron and steel and allied industries by the oil industry. Crude petroleum output had been declining almost uninterruptedly since May, 1925, and the result of this was an intensive and extensive campaign of wild-catting and other new well-drilling, well-deepening, and pipe laying into new fields, which by the last quarter of the year had resulted in a new high record of daily output and had also brought about a demand for large tonnages of iron and steel, as such and in the form of machinery. Statistics showing this demand are not available but it seems clear that it was a potent factor in sustaining output of the heavy industries during the summer.

In the last quarter of the year, more or less sharp curtailment in automobile production, in farm equipment sales and manufacture, and some degree of curtailment in oil country purchases was evident; the first being clearly brought out by the chart. Construction activity, however, was maintained at very high levels, in the face of weakening rentals, an increase in vacancies, the failure of a prominent real estate mortgage house, and the opinion of many of the leaders in the industry that a recession was inevitable if not indeed already overdue. The middle grid shows clearly the astounding record made in 1926 by the construction industry. Engineering projects, such as subways, bridges, and so on, by public bodies and public utilities, made up for a decline in some other types of construction, especially residential; and the Mississippi Valley gained at the expense of some of the eastern districts. The maintenance of a large volume of available credit and investment funds apparently overbalanced during most or all of 1926 other factors of either supply or demand. Of course, in the large cities especially, mounting real estate values and mounting tax rates on these rising values continued

to exert a cumulative urge to the replacement of old and low buildings by taller and modern ones.

A few paragraphs back comment was made on the failure of the railroads to order many freight cars during 1926. It should be said that the situation was different in regard to orders of locomotives, for the total purchases contracted for in 1926 are somewhat in excess of those ordered in 1925. That the railroads have been able to move a record volume of traffic this year without any car shortages except a few of very local and temporary character in the fall of the year, has been due to abundance and good use of tractive power, the keeping of an unusually large proportion of cars and locomotives in serviceable condition, and the attainment of new high records of efficiency in traffic movement. This has been reflected not only in statistics showing high records of train loads and train speed (and therefore ton miles per train hour), low transportation ratio, low consumption of coal per 1,000 ton miles, and record net operating incomes, but also in the type of service which shippers and receivers of freight have found themselves receiving, facilitating at all times free movement of goods through productive and distributive channels. The high records made by industry this year would not have been possible without such service. During the past fall, the number of surplus freight cars was reduced to the lowest figure since 1923, and the fact that the railroads in the face of this have forborne to order freight cars on any substantial scale may indicate among other things their expectations of doing an even more efficient operating job in 1927.

Financial Conditions

Of money and of financial conditions generally in 1926 we have yet to speak. Short-term money rates of all kinds ruled at almost all times during 1926 at levels above those for the corresponding periods of 1925. The final month of the year was the outstanding excep-

tion to this general statement, for money in December, 1926, tended to be somewhat easier than in December, 1925, in spite of the fact that in the meanwhile the volume of all bank credit extended by the commercial banks of the country had very greatly increased. Receding business and prices and the generally liquid condition of most industries, added to the fact that investors had apparently taken off the banks' hands, and paid for out of savings, not only some investments but also a substantial volume of security loans, doubtless were among the principal factors which brought about the year-end ease. Although, subject to seasonal fluctuations, the tendency of money rates has been slightly upward during the year, there has at no time been the slightest danger or apprehension of a credit stringency. The character of the money market is perhaps epitomized by reference to the fact that 1926 has been the only full calendar year since the formation of the federal reserve system in which not a single federal reserve bank, except the New York institution, made any changes in any of its discount rates throughout the year. The federal reserve open-market policy, like the discount rate policy, was one of relative inertness all year. Perhaps the most interesting result of federal reserve policy was the fact that for the first time since 1922 the system added moderately to its gold reserves during the year by paying out federal reserve notes in response to demands for currency, thereby reversing the process which had been pursued for four years. During the latter part of the year the federal reserve ratio for the system as a whole was above that of a year previous.

The securities markets reflected credit ease, the large volume of savings available for investment, and the prosperous conditions and profitable operations of business. Industrial stock price averages rose to the highest figures on record, and railroad stock price averages went above any figures registered since before the war. High grade bond prices rose and yields declined during the

greater part of the year, and at the close, high grade corporate bonds generally were selling on the lowest yield bases at least since our entry into the war, if not since before the war began. This came about in spite of a record volume of offerings of new securities to finance the large construction and expansion programs which were put through during the year, and in spite of the fact also that both the federal reserve banks and the reporting member banks of the federal reserve system disposed of securities on balance. As against these latter influences were the circumstances that the Federal Government in the course of the year reduced its interest-bearing debt by over one billion dollars, and that the net effect of our loans abroad and foreigners' payments to us on account of interest, principal, and repurchase of their own securities may have been a balance of payments actually in our favor, and quite certainly was a balance more favorable to us than in 1925.

Foreign Developments

This leads to some consideration of foreign developments in 1926, especially as affecting conditions in this country. The outstanding factors in the foreign situation were probably the severe depression in Germany, especially during the first half of the year, the prolonged coal strike in England, the devaluation and stabilization of Belgian currency, with the adoption of a gold standard for international payments, the preparations made and groundwork laid for later stabilization of other currencies, particularly of France and Italy, and the rendering of the report of the Royal Commission on Indian Currency and Finance, noted in the last issue of this Quarterly. Throughout the year leaders in finance, business and economic thought labored to create conditions which would stabilize European currency, finance and industry, and bring Europe as soon as possible into a state of economic health comparable with that of pre-war times and somewhere near approaching that of

the United States. It was said in the article a year ago that "development of our foreign trade in 1926 seems hardly likely to afford positive support to expansion in most industries." Events of the year and especially European conditions bore out that assumption. Generally speaking, European business conditions varied from poor to only moderately good. Our relatively small visible export balance for the year was, however, due not so much to restricted European purchases as to the reduced prices at which cotton and wheat and certain other of our important commodities went out and the large volumes and relatively high prices of some of our imports, notably rubber and silk.

The Prospect

The year 1925 ended with business and profits rising to new high levels. The aggregate volumes of both business and profits in 1926 have doubtless exceeded even the favorable records of 1925. The year is ending, however, with business and profits declining, not rising, as they were twelve months ago, and the number of business failures is apparently increasing in more than usual seasonal proportions. The new year will open with at least the following important factors in its favor: abundant and relatively easy money; a high volume of general purchasing power, apart from certain agricultural districts; few conditions of unwieldy inventories; benefits accruing from the advances made during 1926 in operating efficiency in the use both of labor and of plant and equipment; the healthy financial condition of the railroads and the high prices of their stocks, which will enable them to raise money easily for construction or expansion programs, if they so desire; and a gradual, if slight, improvement in European conditions. Unfavorable or neutral factors include the following: the current tendency for profits to decline and failures to increase, and the certainty that keen competition in 1927 will tend further to narrow profit margins; clear signs of

overbuilding in certain parts of the country and in certain types of edifices; the probability that the automobile industry, despite its ever-growing capacity, will not be able to duplicate its volume record of 1926, much less exceed it; the softness of commodity prices, diminishing business men's confidence, and tending to induce curtailment, apart from its effect on the profits of those who produce the commodities; in particular, the unsatisfactory prices of some of the leading agricultural commodities; the possibility of a serious bituminous coal strike beginning on April 1st; and the probability that such stabilization measures as are taken in Europe during 1927 will tend to have immediately depressing influences rather than otherwise, and not improve European purchasing power, except as this is stimulated by foreign borrowing.

A serious business recession in 1927 seems quite unlikely, but the balance of probabilities deduced from the foregoing would seem to lead to the conclusion that during the first part of 1927 at any rate business will fail to maintain the high record of activity set in the last two years. There is a cautiousness evident in the buying policies and general programs of most industries, such as was not prevalent a year ago, which in and of itself seems to portend a further moderate slowing up of basic activity in the immediate future. The key to the puzzle of what 1927 should bring forth seems to be in the possession of the construction industry. If, because of the readiness with which funds can be obtained, building operations go on apace regardless of immediate demand, industrial activity generally may be pretty well sustained throughout the first half of 1927, only to slump off later. On the other hand, if construction slows up soon, there might be a sharp but short recession in the first half of 1927, succeeded by gradual recovery in the second half. Something like the latter seems the more probable of the two. Again, as a year ago, European conditions seem likely to be a factor of

relatively minor effectiveness in changing our own picture for either good or bad, and in any case of much less probable importance than our domestic agricultural situation, especially as that may develop in the latter part of the year.

F. E. RICHTER.

Outwitting the Weather

ON the average, more than fifty million telephone conversations take place each day over the lines of the Bell System in the United States. Rain or shine, hot or cold, under the lash of winter's sleety blasts or amid the flashes of the summer lightning storm, this vast, intimate personal service to the American people carries on day after day. The more inclement the weather, the more do people resort to their telephones. There are appointments to be cancelled or deferred and taxicabs to be summoned. The state of the weather affects the affairs of men in many ways. A sudden storm may cause a veritable flood of telephone calls to rise quickly in traffic channels where, in fair weather, a more tranquil flow prevails. Many portions of the telephone plant are peculiarly susceptible to atmospheric conditions. In order that the service shall not fail in the face of Nature's challenge, the plant must be designed, constructed and maintained so as to be practically immune to the ordinary vicissitudes of the weather. Careful plans for protection against violent downpours and heavy gales are not enough. The sultry, humid summer dog-days and the clear, biting nights of mid-winter would each breed, in the telephone plant, a host of their own peculiar kind of troubles were it not for the vigilance of an army of telephone people constantly bent on outwitting the weather in all of its varied moods. Despite the unremitting care and effort of the construction and maintenance forces, interruptions of the service due to rain, wind, sleet, heat, cold and lightning would be frequent and widespread but for the basal work of the telephone engineers and scientists. These men, who invent, design and test, in the laboratory and in the field, the complex apparatus and methods essential to modern telephone service, must constantly keep in mind the necessity of producing a plant that shall ever be best adapted to withstand the onslaughts of the elements.

It is to a brief review of some of the precautions taken to overcome the deleterious effects of adverse weather conditions that this article now proceeds.

Rain

Water is the uncompromising foe of the insulation of the wires upon which the reliability of the telephone service depends. All telephone wires must be insulated at all points so well that the tiny currents which they convey are prevented from straying from the paths that the wires provide for them. In the case of bare wires sustained by poles, reliance for the necessary insulation is placed on the glass insulators mounted on pins placed in the crossarms, to which the wires are attached at each pole. Even though glass is employed in the manufacture of these insulators, there is a certain amount of conduction of the telephone current over the surface of the glass when it is wet, and this leakage is intensified by the presence of the dirt and dust with which the insulators are prone to become coated. In order to render the insulators effective in wet weather, a portion of the glass is kept dry by molding the lower part of the insulator in the shape of a bell or skirt. The contour of this skirt follows in a general way the form of the pin on which the insulator is supported, but the inner surface of the skirt is separated from the pin by an air space which is made so narrow that rain-drops, splashing on the top of the crossarm, will not enter it appreciably. In the design of these insulators much attention has been given to obtaining the most effective relation between the length of the leakage path and the area of the surface in order to obtain the best insulating properties.

The paper insulated wires in metallic sheathed cables depend entirely for their insulation on the effectiveness of the sheath in excluding moisture. Even the most minute cracks and holes in the sheath cannot be tolerated. When it is realized that no less than 12,000 miles of this kind of cable are being added to the plant of the

Bell System in a single year, it becomes immediately apparent that the greatest care must be exercised in the design and manufacture of these cables to avoid the occurrence of defects in their sheaths that might allow water to reach the delicate paper insulation surrounding the hundreds of copper wires which they contain.

Humidity

To permit the subscribers' line wires, which are generally rubber covered, to be connected readily to the wires in the overhead cables, the latter are equipped at frequent intervals, sometimes as often as every pole, with devices known as "terminal boxes". These terminals contain a small panel of porcelain or wood, studded with brass binding posts to which the rubber covered wires coming from the subscribers' stations may be connected. A small cable, branching off from the main overhead cable, enters the terminal and the paper-insulated copper wires of this branch cable are soldered to the ends of the binding posts at the back of the panel and hermetically sealed to prevent the access of moisture. The fronts of these panels are protected by either removable covers or hinged lids which have been carefully designed to restrict the circulation of air about the face of the panel. Unless these precautions were taken, the dust and dirt, suspended in the air, would collect on the panels and, at times when the humidity is high, moisture would condense on the panels in the same way that pipes in the cellars of buildings are apt to "sweat" under similar conditions, and frequent troubles from low insulation would ensue. This is another instance where thought and care have been exercised to outwit the weather.

It is not alone in the case of these cable terminals that the unfavorable effects of high relative humidity must be circumvented. The flexible cords used by the operators at switchboards to connect the lines together are treated with a waterproofing compound to prevent

the current leakage that would occur in periods of dampness unless such precautions were taken.

In the central offices are to be found large skeleton structures known as distributing frames,—auxiliaries of the switchboard. On these frames great masses of wires, insulated with coatings of enamel and impregnated silk, are used to enable connections to be made and shifted between the subscribers' and trunk circuits and the switchboard.

To overcome the danger of fire spreading rapidly in this mass of insulated wires, each individual wire is enclosed in a braided covering that is treated with a non-inflammable solution. From their nature, these fire resisting salts take up water with avidity. Consequently, the use of these salts must be so controlled that the amounts of water absorbed during periods of high humidity will not be sufficient to endanger the telephone service by causing the salts to creep over the bared ends of the wires thereby producing leakage of the electric currents.

Heat and Cold

The kind of wire that is used largely for the short stretches between pole lines and buildings, has the conductors insulated continuously with a rubber compound. This compound would deteriorate rapidly if it were exposed to the action of sunlight. For this reason, the rubber compound is covered with a cotton braid to exclude the sun's rays. This braid in turn would not last long unless the cotton were saturated with preservative waxes. In order that these waxes may remain in the braid, they are so selected that they will not liquify under the hottest summer sun. On the other hand, they must remain reasonably plastic under the most severe conditions of winter and their ability to resist cracking at low temperatures is a matter to which attention has had to be given. All of this rubber covered wire is carefully tested for insulation resistance before it is placed in service.

Enormous amounts of cable are strung overhead, suspended in rings from wire rope or "strand" as it is termed in telephone parlance. Unless the sags of these cables and their supporting strands are properly regulated with reference to the length of the span between poles, the strand would contract in length, during cold snaps, sufficiently to set up excessive loads in the poles and their guys. Furthermore, in many instances, it is only by suitable adjustment of the sags that the expansion of the cables in hot weather can be prevented from causing the cables to bend and buckle, sometimes even enough for the cables to lift themselves above the suspension strand. If this were allowed to occur to excess, the cables would be liable to crack at the points where the bends occurred.

Likewise, with bare wires attached to crossarms, unless the sags of the wires are carefully regulated, they would be apt to break in extremely cold weather, due to the tightening which occurs as they contract in length. The proper sags to employ are determined by elaborate calculations based on the mathematical laws of the curve which the wires assume and, in these calculations, consideration must be given not only to the change of length of the wires as the temperature varies, but also to their elasticity, that is, the elongation which takes place in them as they are stressed.

One of the interesting properties of metals is that their electrical resistance increases as their temperature rises. In the case of the copper wires in long interurban cables, the changes of their electrical resistance with fluctuations of temperature have required the invention and use of special devices. These cables are frequently suspended aerially. Depending upon the degree of sunshine and other causes affecting the temperature of the ambient air, the resistance of their wires may vary considerably from hour to hour. To enable satisfactory talks to be transmitted through these cables, they are equipped with repeaters. These repeaters are so

delicately balanced electrically that every slight change in the resistance of the cable wires requires their readjustment. By means of ingenious arrangements in which a pilot wire extending through the cable is made to control the repeater adjustments, the necessary regulation is automatically performed and another instance of outwitting the weather must be credited to the telephone engineers.

Some of the apparatus used in the telephone system is exposed to considerable variations of temperature. To ensure proper action and freedom from excessive troubles throughout the temperature range to which they are likely to be subjected, these pieces of apparatus are carefully tested in the laboratories before their design is approved. In a room so hot that one instinctively draws back when the heavy door is opened, may be seen dozens of appliances undergoing searching tests at high temperatures, while not far away, in refrigerating chambers, other tests of identical apparatus are in progress that reproduce the lowest temperatures ever encountered in service.

Wind and Sleet

In the earliest years of the business, before even the most rudimentary forms of cables had been developed, the telephone plants in cities and towns consisted wholly of open wires run overhead. These wires were attached either to frame structures erected on the housetops or to tall poles placed on the curb lines of the streets. These poles frequently carried ten or fifteen crossarms and sometimes many more. On the roof of the central office building would be found a large structure on which the wires, approaching from every direction, were terminated. In the larger exchanges these structures reached huge proportions. As was to be expected, this type of construction was peculiarly vulnerable when sleet formed on the wires, accompanied by high winds. It was no uncommon occurrence for these overhead open wire

plants to be almost completely wrecked during severe winter storms. Sometimes the structure on the roof of the central office building would collapse under the weight of the ice-coated wires and these would be left in a hopeless tangle requiring days and weeks of intense effort to restore the service. In the latter portion of the first decade of the business, as the early forms of cables capable of being placed either underground or aerially became available, the masses of overhead wires in cities began to disappear. The annual report of The American Bell Telephone Company of March 31, 1885, said:

"Great progress has also been made in getting the heavy overhead lines into aerial cables in the cities; this is an important step, and one that is materially reducing the unsightliness of the telephone systems, while adding much to the safety of the wires and reducing the cost of maintenance. There are now 4,300 miles of wire in 69 miles of aerial cables in use." . . . "Some progress has been made in getting wires underground for short distances in the cities, and 1,225 miles of wire underground are now reported."

As Æneas, shipwrecked on a hostile shore remarked, "even these things may one day be amusing to remember"!

Forty years of continuous cable development have resulted in such progress that, today, more than 95% of the forty million miles of wire to be found in the exchange plants of the Associated Companies of the Bell System is in cable. Of the remaining 5%, nearly one-half is accounted for by the rubber covered wire necessarily employed in connecting the subscribers' stations to the cables.

In the case of the toll and long distance wires used for telephone connections between cities and towns, it was not until important inventions and developments in loading coils, repeaters, and special types of cables had been made, during the last quarter of a century, that it became practicable to employ cables to a considerable

extent in giving this class of service between widely separated points.

These toll cables are placed either underground or aerially. When carried above ground they are supported by short, stocky poles which are amply guyed. The result is a type of construction which is practically storm-proof.

A measure of the increasing use of cables in this class of service is afforded by the fact that, in the last decade, the percentage of the Associated Companies' toll wire mileage that is in cable has risen from 32 to 58. During the same period, in the Long Lines plant of the American Company, this percentage has risen from 18 to 62.

These radical changes in the toll and long distance wire plants have resulted in notable gains in the reliability of the service due to the practical immunity of the cable lines from injury due to storms. Important as are the benefits derived from their employment, the universal use of cables for cross-country lines cannot be economically justified. As the traffic grows, they will be employed more and more along the main arteries of conversation, but there must still remain a considerable use of open wires in those cases where a comparatively few circuits are sufficient to handle the traffic.

When laying out the design of these pole lines, decisions must be made as to the stoutness of the poles which should be used, how frequently they should be guyed and how strong the guy strand should be. The telephone engineers have determined the strength of poles of different sizes and of various kinds of timber by breaking hundreds of them, using huge spring balances to measure the loads that are applied. The holding power, in the ground, of the anchoring devices to which the wire rope guys are attached has also been measured by similar means. Records of high wind velocities and of the thickness to which sleet has been found to form on the wires in different sections of the country are consulted and the details of the line design are worked out

so as most effectively to meet the probable conditions of exposure to winter storms. Sometimes, in exceptionally severe storms, portions of the overhead plant are wrecked. This is not due to errors in the engineers' calculations, but because it would be economically unjustifiable to build the entire plant so that it would withstand the worst storms, which occur only at rare intervals. If these were to be guarded against completely, the expense of the plant would be greatly increased and, of necessity, the large additional cost would have to be reflected in what the telephone users pay for service.

Ice

In the underground telephone plant, the conduits, which extend from manhole to manhole beneath the streets, consist of groups of ducts or pigeon holes. Each underground cable is drawn into one of these ducts. Everyone is familiar with the enormous pressure exerted by the expansive force of water when it freezes. If water should be allowed to collect in the ducts, the cables would be crushed and injured when the water froze in winter weather. To prevent troubles from this source, precautions are taken by sloping the conduits so that any water that enters the ducts where they are joined will flow out into the manholes.

Lightning

When Thor hurls his thunderbolts it is not astonishing that so sensitive an organism as the telephone system is put to a severe trial. The energy of a heavy lightning discharge is so great that, in the absence of efficient protective devices, the telephone plant would suffer widespread injury from the destruction of cables and of the apparatus at the subscribers' stations.

It is not necessary that lightning should strike the wires directly to interfere with service. Every flash releases induced electrical charges that surge over the telephone circuits in the vicinity of the storm, threaten-

ing to break through the insulation of wires and apparatus in their eagerness to leap to earth. While it has not been possible to prevent a considerable amount of interruption to telephone service due to lightning, the extent and duration of these interruptions are minimized by the use of devices known as lightning arresters. From the very beginning of the telephone art, the ingenuity of the engineers has been taxed to develop devices of this kind which will allow the surges produced by lightning flashes to pass harmlessly to earth.

In some of the earliest lightning arresters, serrated metal plates, connected to the telephone wires, were placed with their teeth projecting close to a grounded strip of metal, but separated from it by a small air-space. When the surges in the wires raised their electrical pressure to a sufficiently high point, arcing would take place across this intervening air-space, thus relieving the electrical stress in the wires and apparatus.

Subsequently this somewhat crude form of arrester was superseded by two little blocks of carbon separated by a thin sheet of mica. One of these blocks was connected to a telephone wire, the other to earth. These improved devices were much more effective than their predecessors in protecting against lightning. In fact, so sensitive were they that, during a heavy thunderstorm, it was no infrequent occurrence, even in exchanges of moderate size, for hundreds of telephone stations to be put out of service, there to remain until the maintenance men of the telephone company came to restore the arresters to their normal condition.

An important step forward was taken when an improved form of carbon became available and for one of these carbon blocks there was substituted a small piece of carbon, inserted and sealed in a porcelain block. This new arrester can be so accurately made that the mica separator, formerly employed, is now no longer required, reliance being placed on a tiny air-gap. These improved arresters are so much more effective than the type which

preceded them, that they have greatly reduced the number of stations whose service is affected at the time of a lightning storm.

* * *

While instances such as have been described above are by no means all of those in which the skill of the telephone workers is called upon to prevent the service from suffering frequent interruptions at the hands of the weather, they serve to illustrate the varied nature of the precautions which contribute to its high degree of reliability. In this, as in every other phase of the telephone art, it has been the constant aim of a large corps of trained specialists never to rest content with the apparatus and methods of the present, but continually to strive to improve; to use the existing things as a foundation on which to build better for the future. This spirit of evolutionary progress has been an outstanding characteristic of the telephone art from its humble beginning and it is this same spirit of strenuous endeavor to improve that actuates and stimulates the workers of today in every division of the complex and diversified telephone field.

FREDERICK L. RHODES.

Quality of Telephone Materials

MEN, methods and materials are the foundations of telephone service. Good service requires a competent and devoted staff. It requires methods of operation which are fast, accurate and efficient in the use of plant. But men and methods, however good in themselves, are badly handicapped unless the material equipment of switchboards and lines is of the quality required for good service. For the achievement of good telephone service—the objective of the Bell Telephone System—every employee is, in some measure, responsible; and every member of the System, therefore, has a vital interest in the quality of telephone materials.

The quality problem of the telephone industry is tremendously complicated. The plant of the Bell System is comprised of about 100,000 different kinds of parts. Many of these are intricate; many have to be manufactured with exquisite precision. Most of them are manufactured in large quantities, and for many the annual production is in millions.

Through fifty years of progress the telephone has grown to its present stage of vigorous maturity. Brilliant imagination has led the way, and still will lead, to novel telephone discoveries. More and more, however, in the future, improvements in service will come by refinement in design and manufacture. Increasing attention is being given to standardization of types by good design, and uniformity of quality steadily assumes growing importance. Standardization of quality in addition to that of design is emphasized and interest constantly attaches to the methods by which quality is standardized and controlled.

Each item should be perfect: each proportion and dimension, the ideal magnitude. But if the wagon is hitched to the star of perfection the ride may cost more than the passengers can pay. So the development engineer aims to strike a balance between performance and

cost. In designing a loading coil, for example, he determines the composition and proportions of its parts with suitable tolerances. He specifies, for example, that its inductance over the proper range of frequencies shall be between certain values. Such tolerances allow for variability in the compositions of materials and in human effort.

The manufacturer must meet the specification requirements, but certain principles control the extent to which he should go in building quality into his product. If he manufactures so that in each lot every unit is within the tolerances, then most of the units will be found within limits much narrower than the designer intended to specify. It is generally much more economical to set up the manufacturing process with this fact in mind and allow the small percentage of the product which slightly exceeds the tolerances to be later rejected. In well controlled manufacture the excess will be found in a very small percentage of the product, and practically always the deviations will be small.

In this discussion of quality, as it obtains in high grade manufacture, it should be clear that we are not discussing quality in the ordinary sense of good as contrasted with bad, nor comparing what is serviceable with that which is utterly unserviceable. The discussion assumes that conformance with specifications is the rule, and the spotlight of attention is concentrated on those small marginal deviations which affect service value so little that economy questions their rejection.

Quality of apparatus is chiefly a problem of design and manufacture. The Western Electric Company, as manufacturer of telephone equipment for the Bell Telephone System, is striving to meet the needs of its principal customer, and hence striving for what may be termed "The Economic Standard of Quality"—economic in an overall sense, taking into account the life history of the product. The production process, broadly defined, is divisible into four steps—design, selection of raw

material, fabrication, and inspection. Obviously, all of these play important roles in determining the quality of the product. In the design of a telephone relay, for example, the aim is to achieve a balance between operating efficiency and cost, due account being taken both of first cost and charges for maintenance and replacement. The objective of design is economic quality. Similar statements apply to the selection of raw material, and to the fabrication process. It should be clear then in the following discussion of the relation of inspection to economic standards of quality, that the inspection engineer claims no monopoly of the field. He merely enjoys the same unprejudiced environment which encompasses the points of view of the designer and the manufacturer.

Inspection Engineering

In its relation to manufacture, inspection engineering has two objectives—to protect the consumer and to promote economy of production. Let us consider the manufacturing process simply from the viewpoint of these fundamental objectives. We picture, as in Fig. 1, a score and more of raw materials—iron, copper, cotton, rubber, etc.—fed into the manufacturing process and operated upon by the directed energy of men and machines, issuing as telephones and other materials of communication. A complete or one hundred per cent inspection at the exit protects the consumer. The scheme of Fig. 1(a) achieves the first objective but ignores economy. Fig. 1(b) represents a more economical plan. It involves successive steps of inspection, often inspection by sample, paralleling the various steps of manufacture.

Such inspection is not only a protection to the consumer but also the means for controlling the character of materials passing from one stage to the next succeeding stage of evolution into operating telephone equipment. Raw material is inspected before passing it on to the first

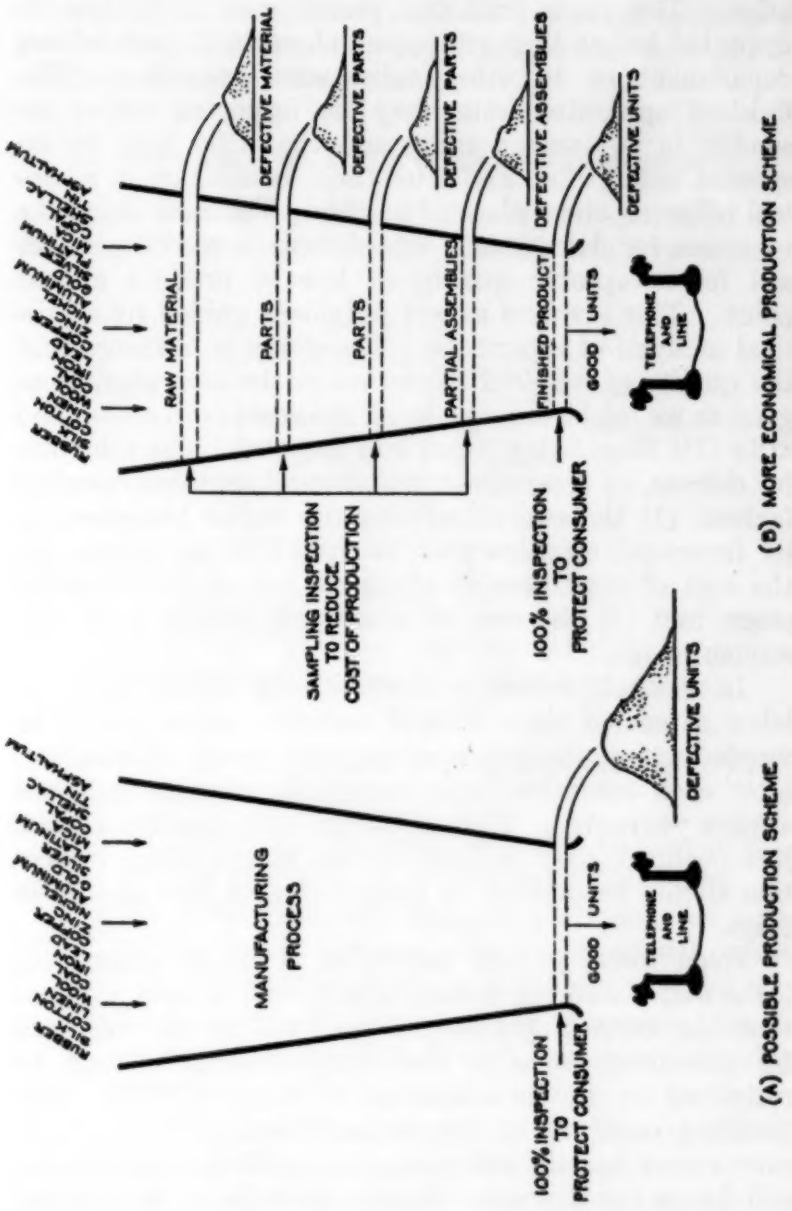


Fig. 1—Diagrammatic View of Manufacturing Inspection

stage of manufacture, which may be a punch-press operation. The parts from the punch-press may then be inspected before they are passed along to the assembling department or to other subsequent operations. The finished apparatus units may be inspected before assembly in equipment units; and the latter may be inspected both before and after their installation in a central office or other place of service. For each stage the tolerance for defectives is established—a working standard for acceptable quality of lots of product at that point. This involves expert judgment guided by statistical analysis of experience. The object is to insure that the quality of material passed on to the next stage is as good as we ought to make it, all the costs both before and after this stage being taken into account. The tolerance for defects, so determined, will depend on three essential factors: (1) the cost of refining the earlier processes, as by improved machinery or more skillful personnel, (2) the cost of inspection to eliminate defects at the given stage, and (3) the cost of remedying defects at a subsequent stage.

In general, defective raw material should have no labor expended upon it, and defective parts should be weeded out at the points where they occur. To inspect after each operation costs money, however, and is not always warranted. Such economic consideration as was just outlined, may indicate certain stages where inspection should be omitted or combined with that at a later stage.

Even where process inspection is clearly warranted, if the manufacturing process is perfected to such a degree that the average product is well within the tolerance for defectives, then at that stage inspection may be restricted to the examination of samples, only, with resulting economy of inspection effort. Chance, however, enters into the selection of the units in each sample; and hence the character of any given lot is determined only approximately, or within limits. The laws of

probability therefore play an important part in sampling inspection, and statistical methods based on these laws are used in the organization of inspection, and in the analysis of inspection results.

Fundamental Objectives of Inspection

As illustrated by Fig. 2, the two fundamental objectives of inspection may be divided into five objects.

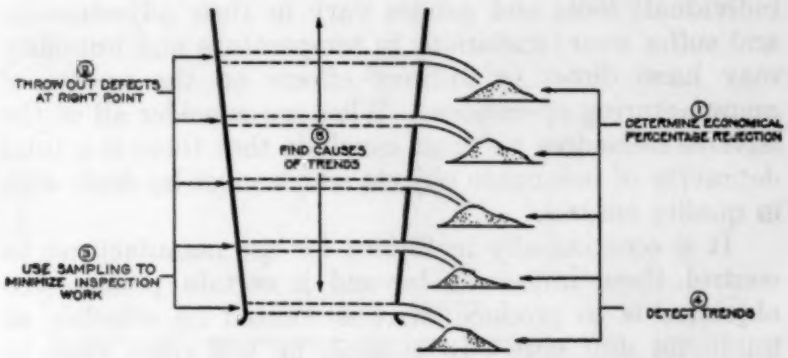

② THROW OUT DEFECTS AT RIGHT POINT
① DETERMINE ECONOMICAL PERCENTAGE REJECTION
③ FIND CAUSES OF TRENDS
⑤ USE SAMPLING TO MINIMIZE INSPECTION WORK
④ DETECT TRENDS

Fig. 2—Five Objects of Inspection in Schematic Illustration

Of these the first three have already been discussed. The complete list is as follows:

(a) To determine for each step the economic percentage rejection, or tolerance for defectives.

(b) To reject defective material and parts at such points in the chain of production as will make the net cost of rejection a minimum.

(c) To determine for each step the minimum amount of inspection which will suffice to give economic control of quality.

(d) To detect failures of desired quality control as evidenced by fluctuations and trends.

(e) To discover the causes of such fluctuations and trends in order to secure improved control.

In addition to the three objects previously discussed two others are of importance, namely, detection of trends and finding their causes. To understand these we must consider further the variability of quality and the manner in which it is governed by the laws of chance.

There is nothing mysterious about the influences which cause random variations in quality of manufacture. The raw materials used in any process vary more or lesss in their properties; the physical and mental condition of the operatives vary from time to time and with the individual; tools and gauges vary in their adjustments, and suffer wear; variations in temperature and humidity may have direct or indirect effects on the results of manufacturing operations. When we consider all of the adverse influences we must conclude that there is a total depravity of inanimate objects which must be dealt with in quality control.

It is economically inefficient for the manufacturer to control these influences beyond a certain point. His objective is to produce what is wanted on schedule at minimum unit cost. In general, he will come close to attaining it by allowing a certain average percentage of defectives to emerge from the chain of productions, there to be separated and salvaged. The manufacturer aiming at what is the economic per cent of defective units is like a rifleman shooting at a relatively small bull's-eye. The results are bunched in and around the bull's-eye, but there is more or less scattering. Corresponding to each shot of the rifleman is a "lot" or "batch" from the factory.

If we classify the results of inspection according to the numbers of lots found with various percentages of defectives, plot the points, and draw a curve to represent them, we obtain a curve like Fig. 3. It is an ordinary frequency curve showing the distribution of results according to their frequencies of occurrence. Each lot may be considered merely a sample of what the process would produce if it ran on forever under the same con-

stant influences. The percentage defective in any given lot appears to bear no particular relation to that in any other.

When a considerable number of lots are taken, however, the average per cent of defectives falls very close to a certain number. This is a number which is found time and again in similar trials. It is the economic percentage if the process is adequately controlled, and hence

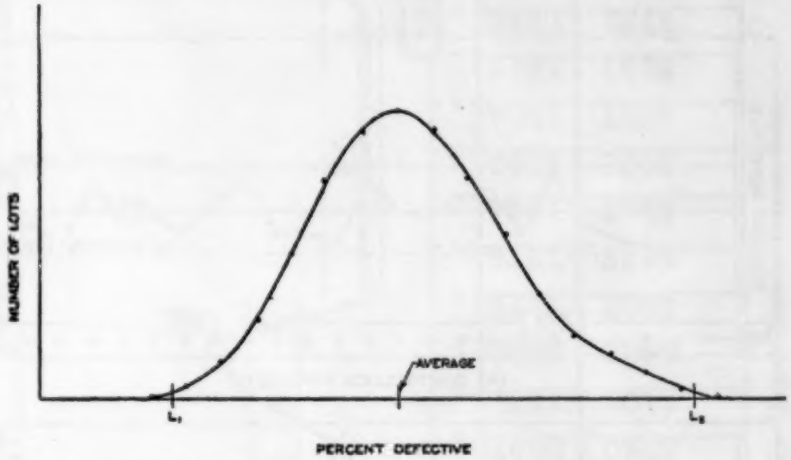


Fig. 3—Typical Distribution of Lots according to the Frequencies with which different Percentages of Defectives occur in them

should be the manufacturer's bull's-eye. The actual percentages of defectives in the various lots are grouped about this average. Evidently, in well controlled manufacture, a complex system of causes is always at work behind the scenes, permitting the number of defectives in particular lots to vary at random within certain limits. These limits can be established on the basis of experience and probability. The causes behind the scenes also constantly restrain *the average percentage* of defectives to a rather definite value.

With this conception, the curve of Fig. 3 may be considered a visible expression of certain laws of probability which apply to the manufacturing process. These

laws enable one to set limits within which the results may be expected to fall. For example, in the figure, L_1 and L_2 are so determined that 99 per cent of the lots produced will have percentages of defectives within these limits.

Quality Control

Fig. 4 is a time chart showing these limits as horizontal lines on either side of a line which represents the

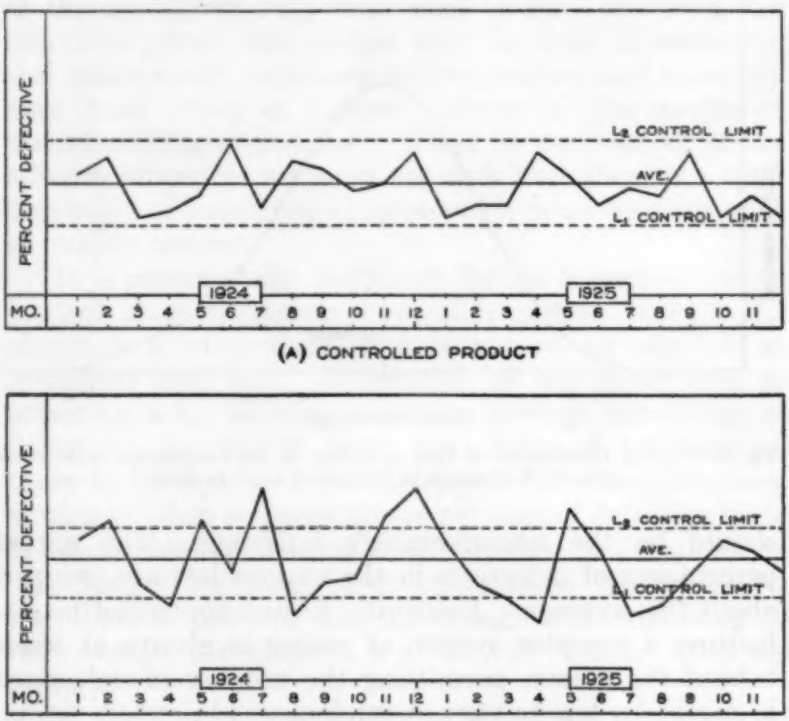

PERCENT DEFECTIVE
L2 CONTROL LIMIT
AVE.
L1 CONTROL LIMIT
1924
1925
MO.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
(A) CONTROLLED PRODUCT
PERCENT DEFECTIVE
L2 CONTROL LIMIT
AVE.
L1 CONTROL LIMIT
1924
1925
MO.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
(B) UNCONTROLLED PRODUCT

Fig. 4—Typical Quality Control Charts

process-average percentage of defects. This Quality Control chart is a new development. It is of great practical value in seeking the fourth economic object of inspection, the detection of significant fluctuations and

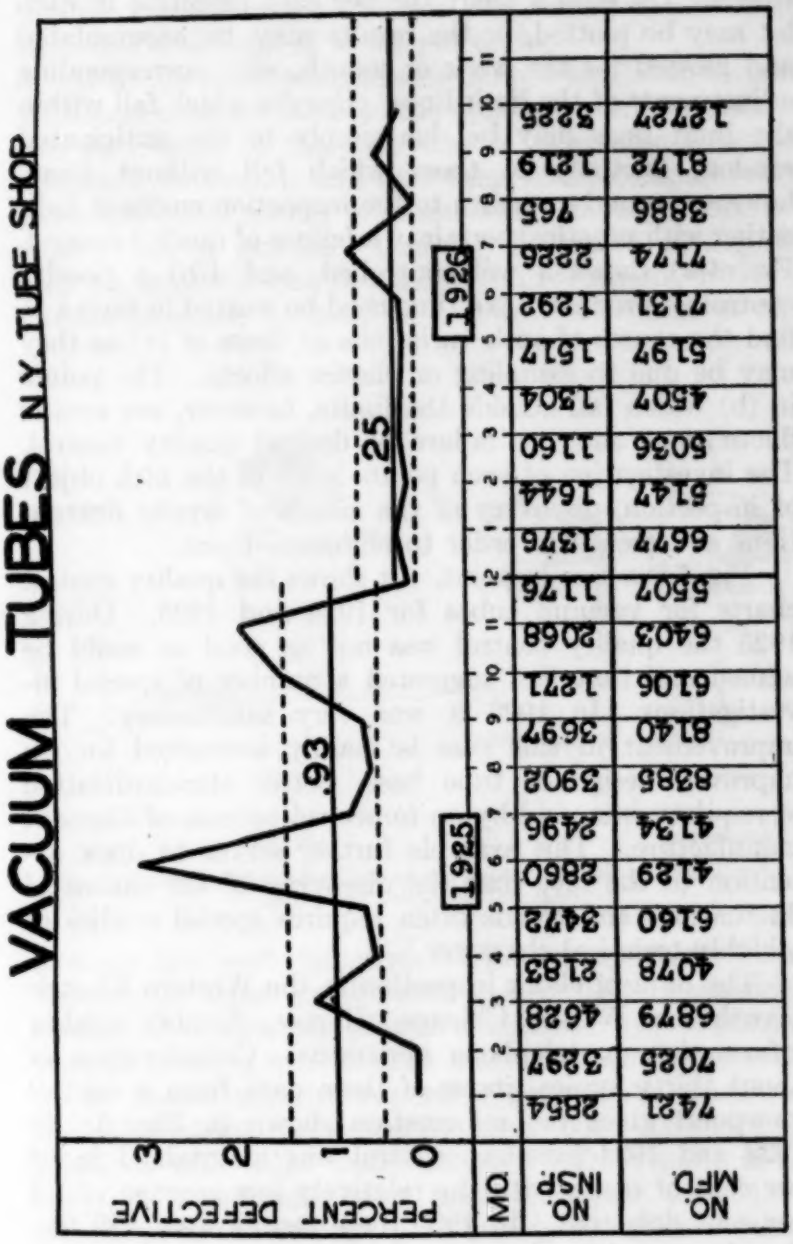


Fig. 5—Quality Control Chart for Vacuum Tubes

trends. On such a chart the per cent defective in each lot may be plotted, or the results may be accumulated and plotted for the week or month, with corresponding adjustments of the limit lines. Results which fall within the limit lines may be due simply to the anticipated random fluctuations; those which fall without them, however, sound an alarm to the inspection engineer indicating with practical certainty a failure of quality control. Fig. 4(a) shows a well-controlled, and 4(b) a poorly-controlled product. No time need be wasted in trying to find the causes of such variations as those of (a) as they may be due to sampling or chance effects. The points in (b) which fall outside the limits, however, are erratic fluctuations showing failure of desired quality control. The investigation of such points leads to the fifth object of inspection, discovery of the causes of erratic fluctuations and trends in order to eliminate them.

Fig. 5 is a case in point. It shows the quality control charts for vacuum tubes for 1925 and 1926. During 1925 the quality control was not as good as could be wished and that fact suggested a number of special investigations. In 1926 it was very satisfactory. The improvement in this case is mainly accounted for by improved design of tube base, better standardization of requirements, and by an improved process of filament manufacture. This example further serves to draw attention to the fact that the discovery of the causes of fluctuations and trends often requires special studies of a highly technical character.

The data of check inspection in the Western Electric Hawthorne Works, Chicago, Illinois, furnish quality information on telephone apparatus. Consideration of about thirty typical items of these data from a control viewpoint gives the information shown in Fig. 6. In 1923 and 1924 excellent control was maintained in 68 per cent of cases, with the relatively low average of 1.4 per cent defective. In 1925 these results were still further improved, and in the first nine months of 1926

quality control rose to 84 per cent, while the average defective was reduced to 0.8 per cent.

Although exact comparisons are not available, certain collateral evidence leads to the opinion that these results are very close to the best that is attainable from an economic viewpoint, and that they would compare very favorably with results of manufacture in any other industry. It is generally true, as illustrated in Fig. 6, that an improvement in quality control results, without further increase in cost, in a downward trend of the

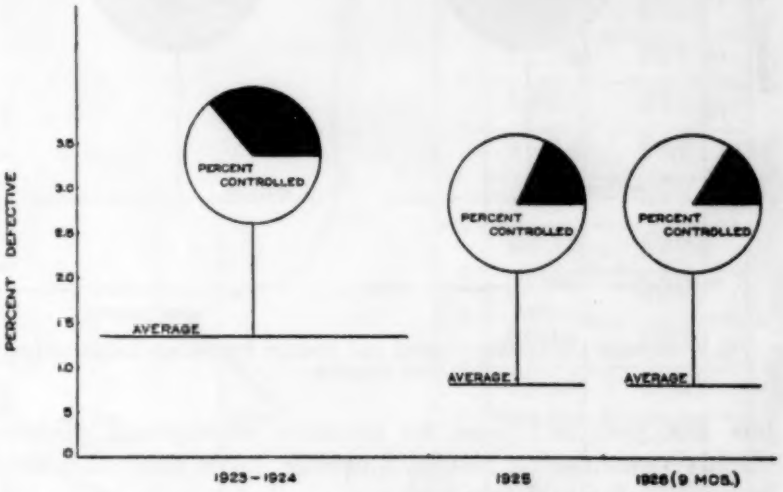


Fig. 6—Summary of Quality Control and Average Percentage Defective for Hawthorne Telephone Apparatus

average per cent defective. While many factors contribute to these good results, inspection engineering studies have recently played an increasingly important part in focusing attention on matters of quality control.

In recent months inspection engineering studies of Bell Telephone Laboratories have been extended to relations with other manufacturers. The results of inspection operations have indicated that with these suppliers, on the average, good quality control is obtained in only about 28 per cent of cases. On the average also

about 7 per cent of the material offered fails to meet requirements, and must be eliminated by Western Electric inspection. The results for 1925 and 1926 are illustrated in Fig. 7. Cooperation has been established but

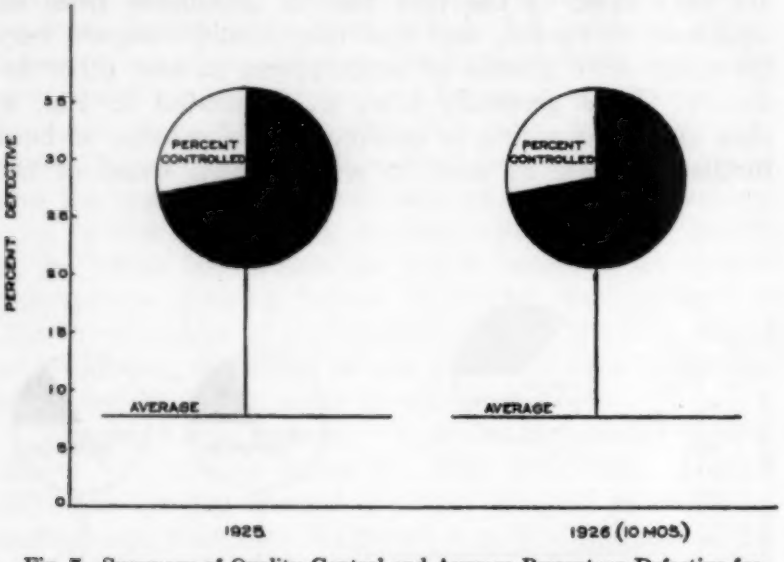


Fig. 7—Summary of Quality Control and Average Percentage Defective for Other Supplies

has not yet had time to produce widespread effects. Highly encouraging results however, have been obtained in some individual cases.

An interesting case of such cooperative inspection studies, with a manufacturer of drop wire, is shown in Fig. 8. During 1925 his control was poor and about 9 per cent of his product was defective. The first inspection engineering conference with this supplier was held in the latter part of 1925. At that time his record was reviewed and the more important types of defects were discussed, with their probable causes. The supplier then adopted an improved plan of inspection and attempted better control of his processes. During the first ten months of 1926 his product was controlled in about 60 per cent of cases and the average defective fell

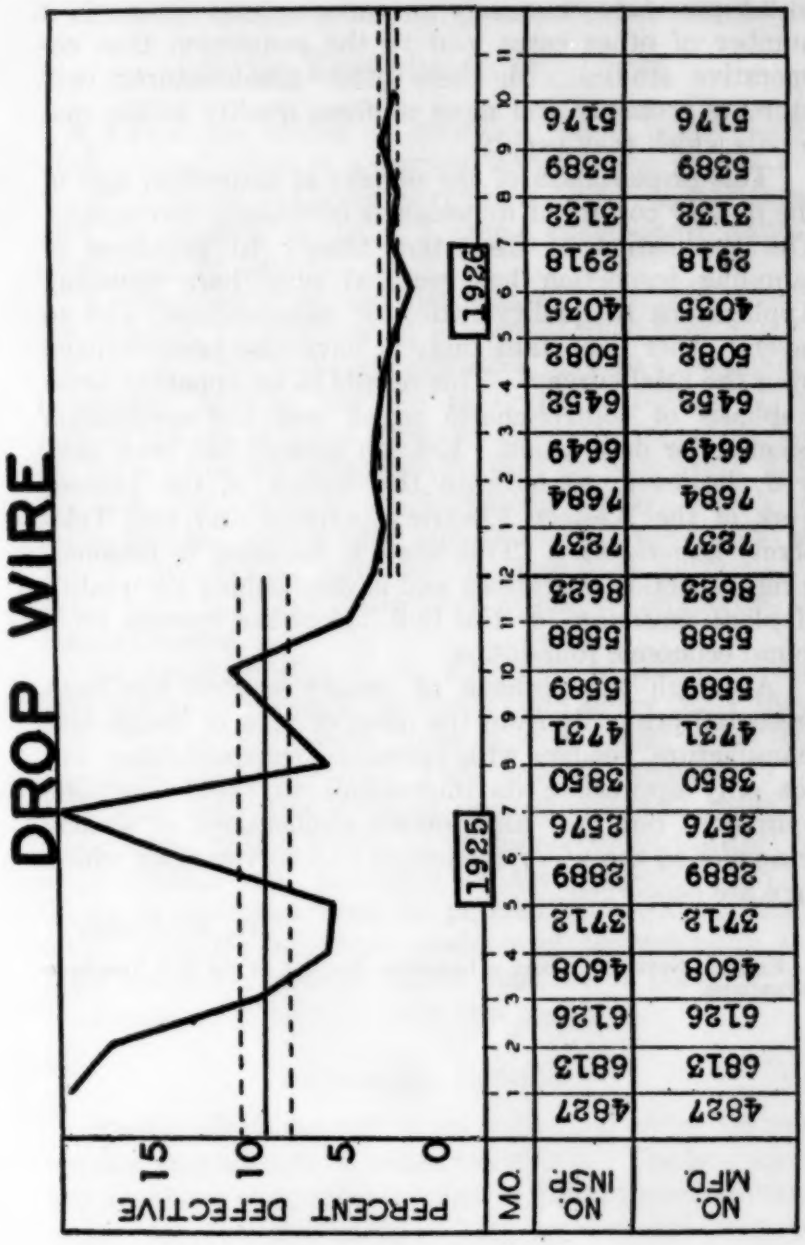


Fig. 8—Quality Control Chart for Drop Wire

to 2.5 per cent. Similarly encouraging experiences in a number of other cases lead to the conviction that co-operative studies with these other manufacturers will promote economy and more uniform quality in the materials which they supply.

This presentation of the objects of inspection and of the quality control of materials is necessarily incomplete. The application of inspection theory to problems of sampling inspection has received only bare mention. Applications to quality rating or measurement, and to several other important matters have also been omitted from the brief survey. This results in an apparent over-emphasis of control-charts which was the application selected for description. Enough ground has been covered, however, to indicate the nature of the pioneer work of the Western Electric Company and Bell Telephone Laboratories. This work is resulting in rationalizing inspection operations and in establishing the quality of plant materials for the Bell Telephone System on a sound economic foundation.

Although the problem of quality control has been presented primarily from the point of view of design and manufacture, readers with operating responsibilities will not only appreciate its importance to their telephone equipment but may also foresee applications of similar principles to the wider economies and service with which they are concerned.

R. L. JONES.

EDITOR'S NOTE: Mr. Jones is Inspection Engineer of the Bell Telephone Laboratories.

Some Distinguishing Characteristics of the Telephone Business

AFTER the taking of testimony on a rather technical point in a certain lawsuit, one of the attorneys was heard to remark: "Why, that witness isn't an expert, is he? I could understand almost everything he said."

The layman often assumes that all technical subjects are obscure. Too often he is content that they should remain so. Yet technical processes play an increasingly important part in the life of every individual. The man in the street is but dimly aware of the means whereby he is provided with services that he uses every day. He sees, for example, the telephone through which he talks, but has only a hazy idea of all that lies behind it. He is disposed to think of the telephone business as being much like any other large business, commercial or manufacturing.

As a matter of fact, the supplying of telephone service differs in its very essentials from every other business. These differences have a vital bearing on the operation of the service. They are well understood by telephone men; but a better understanding of them by the general public would be of assistance in the further improvement and extension of the telephone service. There is particular need for popular appreciation of the effect upon the telephone business of the extensive and long continued growth which has taken place in the total number of telephones in this country.

Increasing Intricacy

Every telephone call is an individual order for connection with a single, specified telephone. The business of the telephone companies consists of filling these individual orders for one call each, as fast as they are received. This necessitates setting up for every customer the par-

ticular connection desired out of all the myriad connections that are possible.

Few people outside the telephone business realize that the number of possible connections increases very much more rapidly than the number of telephones. An exchange with six subscribers' lines has fifteen possible connections. If the number of subscribers' lines increases to 6,000, the number of possible interconnections increases, not merely in the same proportion (which would bring it to 15,000), but in so much greater proportion that it amounts to the staggering total of 17,997,000. The reason for this is, of course, that every new telephone must be capable of connection with every other telephone in the system. Each telephone added to the system adds as many possible connections as there are telephones already connected. This, perhaps, more than anything else, brings out the extent to which the telephone system grows in complexity as it grows in size.

Telephone growth carries with it problems widely different from those that come with the growth of other businesses. The telephone company provides and installs an instrument at each subscriber's premises. It provides the necessary circuit connecting this instrument with the central office switchboard. At the manual switchboard it provides multiple terminals for every subscriber's line: that is, each line is connected with as many terminals as there are sections of the switchboard. In a board consisting of 20 sections and serving 6,000 lines there are 6,000 times 20 terminals, or 120,000 in all. Every operator has before her a terminal for every subscriber's line connected with the exchange, and can therefore easily put through an incoming call for any line desired. It will be seen, however, that when a new telephone is installed the new line must be connected, not merely with one terminal, but with as many terminals as there are sections in the switchboard. Thus the board becomes increasingly more intricate as it becomes larger. In a single switchboard of the largest type used in this

country there are over two million soldered connections, more than 4,000 miles of wire and 15,000 of the tiny electric bulbs, used as signals to notify the operator whenever a subscriber picks up his telephone receiver or replaces it on the hook.

The increasing intricacy of the apparatus sets a limit to the size of a switchboard beyond which it is not practical to enlarge it. When that limit is reached in any given community another board, i.e., another central office, is established. Provision must, of course, be made for effecting intercommunication among subscribers connected with different central offices. The trunk and long distance lines by which this is accomplished involve heavy expenditures for cable and other equipment and for conduit or pole line construction and maintenance. As the number of telephones increases, the demand for toll and long distance connections increases also. The telephone company is obliged to provide more and more of these expensive plant facilities to meet the public's needs. The amount of new capital investment which must be attracted into the business becomes greater and greater. Yet the service always remains a highly individualized service sold at retail, one call at a time.

A Nationwide Personal Service

The individual, personal character of the service rendered precludes the telephone companies from handling the traffic wholesale as is possible for certain other public services. Railways, for example, transport many times as much traffic over the same lines of track during the rush hours as at other times. Telephone conversations, however, must have a clear track all the way from the one telephone to the other. Even the most modern equipment and methods, which permit the simultaneous transmission of several messages between one central office and another over a single pair of wires, still leave the capacity of local telephone circuits strictly

limited. It is not practicable to have the wires connecting a telephone with its central office carry more than one conversation at a time. It is only the trunk wires connecting different central offices that can carry economically and efficiently half a dozen messages simultaneously.

The telephone company is more or less like a railway that is compelled to run a special train for every passenger. Not only that, but it is also compelled to keep the local line over which this special train is moving free of other traffic while the passenger is being transported. Moreover, the telephone may be likened to a railway whose tracks extend to the premises of every prospective passenger, with a private station at the end of each line for that customer's personal use. It will be seen that the operation of such a railway would become more and more complex if there were a substantial and long continued increase in the number of customers for whom this private line service had to be supplied.

Some Compensating Economies

Faced with these exacting conditions, the telephone companies have been notably successful in their efforts for economical service. They have worked unremittingly to offset, as far as possible, the effects of increasing intricacy of telephone apparatus and operation. The telephone system as a whole is a nationwide organism compounded of a myriad parts. Yet the interplay of one part with another is coordinated even across the continent. It is a going concern, that serves as it grows. Renewals and replacements are made without suspension of service. Every detail of this far flung network is subjected to searching scrutiny in the unceasing quest for better and more economical equipment and methods of operation. In administrative technique, in operating practice, in construction and maintenance, improvements and economies are effected wherever the opportunity is found. Telephone research has not only given

American telephone users an increasingly efficient but also an increasingly economical, telephone service. It has not waited for improvements to force themselves on the service, but has painstakingly and unremittingly sought for a quicker or better way to do things.

Engineering developments have, for example, made possible the use of small wires for communication over distances which would otherwise have required extremely large wires, the use of one circuit to do the work of several, the use of less expensive metals and alloys in telephone equipment, and innumerable other economies. It is conservatively estimated that only eight engineering developments of this kind have saved $465,000,000 in initial investment and $70,000,000 in annual expenses. The total savings which have resulted from telephone research have gone far toward counteracting the effect of the cumulative increase in the intricacy of the business which is the inevitable concomitant of telephone growth.

RICHARD STORRS COE.

Bust of Alexander Graham Bell is Presented to Smithsonian Institution

A BUST of the telephone's inventor, Alexander Graham Bell, the work of the sculptor, Victor Salvatore, was presented by the American Telephone and Telegraph Company to the Smithsonian Institution in Washington, D. C., on December 9, 1926, at the annual meeting of the regents of the Institution.

Every member of the Board was present for the ceremony. Chief Justice William H. Taft, Chancellor of the Board of Regents, presided, and around the table sat Vice-President Charles G. Dawes, U. S. Senators Reed, Smoot, George Wharton Pepper and Woodbridge N. Ferris; Representatives Albert Johnson, R. Watson Moore, and Walter H. Newton; Hon. Henry White, Hon. Irwin B. Laughlin, Charles F. Choate, Jr., Robert S. Brookings, Frederick A. Deland, and Dwight W. Morrow. The Secretary of the Smithsonian, Dr. Charles D. Walcott, also was present. Mrs. Gilbert Grosvenor, a daughter of Alexander Graham Bell, unveiled the bust.

Mr. Gifford's Address

The address of Walter S. Gifford, President of the American Telephone and Telegraph Company, in presenting the bust was as follows:

Mr. Chancellor, Regents of the Smithsonian Institution, and Mr. Secretary:—The stately presence and the hearty genial smile of Alexander Graham Bell were for many, many years familiar to these halls. Now that he is gone, we of the Telephone which he invented ask the privilege of seeing to it that, as his memory will always remain here with you who were associated with him in the conduct of this great institution, so also his face and the spirit that always actuated him shall continue to be familiar to those who come in and out of this building, whether as workers, as students, or simply as visitors.

To us of the Telephone, history presents the figure of Alexander Graham Bell as that of a young man of 29 with black hair. To you he is primarily the distinguished citizen of his later years, with white hair and full white beard. But whether of few or of many years in age, his eye and his smile were always the same,—keen, radiant, generous, genial, even jovial in his enthusiastic interest in all that concerned the welfare of his fellowmen. Alexander Graham Bell was always young in spirit,—young in his loyal companionship with others, young in his engrossing devotion to the service of the unfortunate, young in his absolute confidence in Life. The years brought no difference in his spirit. His spirit was always the same.

But although our closest association with Alexander Graham Bell was in his earlier days, we of the Telephone as a matter of fact usually think of him, as you do, in his later years. Accordingly we have asked our sculptor to present in this portrait the young spirit of this man, not in his early years when he invented the telephone, and when he was only at the beginning of his great career, but in the full maturity of his riper manhood, in his large versatility, when he had accomplished so much, when he had gone forth into other fields and in every field had wrought fruitful achievement.

So, as we of the Telephone see in this portrait the Inventor of the Telephone, may Radio see no less the inventor of the Photophone, the first Wireless; may Surgery see the inventor of that device which preceded the X-Ray in the merciful location of foreign substances in the body; may Aviation see the friend and champion of Samuel P. Langley and the Experimenter of the Tetrahedral Kite; may Naval Engineering see the inventor of the Hydrodrome; may the Deaf see him who all his life was their Teacher and Benefactor; and may all who work for the improvement of the human race see the tireless Student of Heredity, Eugenics and Longevity.

Alexander Graham Bell was for nearly thirty years, from 1893 to his death in 1922, a Regent of the Smithsonian Institution. For the same long period of time he was a member of the Executive Committee of this Board. You know his services in this capacity better than I. But his earliest association with this Institution is specially significant to us, and it is a common bond between the Smithsonian and the Telephone. On that occasion this Institution in the person of its great first Secretary, Joseph Henry, rendered a most important service to humanity and the future. It was in March, 1875, before Bell invented the Telephone. The incident happened in one of these rooms, possibly in this very room. Bell was at that time thoroughly worn out and very much discouraged. In all lines of work, in all the triumphs of life, great discouragement often precedes the splendid moment of final success. Let me read to you from Bell's own account of it in a letter to his father and mother written on his return from Washington to Salem:—

> "I am now beginning to realize the cares and anxieties of being an inventor. Flesh and blood could not stand much longer such a strain as I have had upon me. You seem to think that my anxieties are over, when in truth they are really only beginning.
>
> "When I was in Washington," Bell goes on, "I had a letter of introduction to Professor Henry, who is the Tyndall of America. I had found that some of the points I had discovered in relation to the application of acoustics to telegraphy had been previously discovered by him. I thought I would, therefore, explain all the experiments, and ascertain what was new and what was old. He listened with an unmoved countenance, but with evident interest to all, but when I related an experiment that at first sight seems unimportant, I was startled at the sudden interest manifested. He started up, said, 'Is that so? Will you allow me, Mr. Bell, to repeat

your experiments, and publish them to the world through the Smithsonian Institute, of course, giving you the credit of the discoveries?'

"I said it would give me extreme pleasure, and added that I had apparatus in Washington, and could show him the experiments myself at any time. We appointed noon next day for the experiment. I set the instrument working and he sat on a table for a long time with the empty coil of wire against his ear listening to the sound.

"I felt so much encouraged by his interest," Bell continues, "that I determined to ask his advice about the apparatus I have designed for the transmission of the human voice by telegraph. I explained the idea and said, 'What would you advise me to do,—publish it and let others work it out; or attempt to solve the problem myself?' He said he thought it was 'the germ of a great invention,' and advised me to work at it myself instead of publishing. I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties. His laconic answer was, 'GET IT.' I cannot tell you how much these two words have encouraged me."

Bell went ahead and "got it." A year later, on March 10, 1876, from his little laboratory on the top floor of his boarding house at 5 Exeter Place, Boston, Bell telephoned his assistant, "Mr. Watson, come here; I want you."

Alexander Graham Bell was grateful to Joseph Henry for that encouragement all his life. No less, I am sure, was he grateful to this Institution. So too with us, the scientific sons and heirs of Alexander Graham Bell, with our reverence for the memory of Joseph Henry and our appreciation of this noble center of science and culture,

I assure you, gentlemen, that as we come here today there is in our feeling something of gratitude for that vital encouragement from the great Secretary of the Smithsonian to the young Inventor of the Telephone just at the time when he needed that encouragement most.

Mr. Chancellor, Gentlemen of the Board of Regents of the Smithsonian Institution, and Mr. Secretary, in behalf of the American Telephone and Telegraph Company, and in commemoration of the 50th anniversary of the birth of the Telephone, I present to you this bust of Alexander Graham Bell.

Abstracts of Recent Technical Papers from Bell System Sources

Loading for Telephone Cable Circuits,[1] by D. W. Whitney. This paper summarizes the principal characteristics of the loaded telephone line and discusses the major improvements in loading. Up to 1900 there was a general avoidance of the use of cable in the toll telephone plant, due to the high attenuation and distortion of speech currents not experienced in open wire lines. By the use of the loading coil and the telephone repeater, a network of toll cables has grown very rapidly which now connects the large population centers of the Atlantic seaboard and the upper Mississippi Valley region.

Electric Annealing of Magnetic Materials for Telephone Apparatus,[2] by W. A. Timm. This paper briefly describes the annealing equipment used by the Western Electric Company prior to 1909 and some years afterward at the Hawthorne plant, in contrast to the more recently installed electrical equipment.

The Problem of Secondary Metals in World Affairs,[3] by F. W. Willard. Preliminary to the discussion of the secondary metal industry, the author gives a brief statistical survey of the rate of depletion of the world's primary metal resources along with a study of metal production in the United States.

The rapid rate of exhaustion of known resources is emphasized. Graphs also show the relation of prices and production of copper and lead in the United States over a period of 40 years.

Each important economic metal is discussed briefly showing how its present commercial uses affect its return through the secondary market. Attention is di-

[1] To be published in the Proceedings of the Telephone and Telegraph Section of the American Railway Association.

[2] Trans. American Soc. Steel Treat., p. 782, Nov., 1926.

[3] Industrial & Eng. Chemistry, p. 1178, Nov., 1926. Presented at the Round Table Conference on the role of chemistry in the world's affairs at Williamstown, Mass., Aug., 1926.

rected to the degradation of metals in use, forever eliminating them for re-use. Platinum, though not generally classified among economic metals is treated briefly because of its key importance in certain industries. The seriousness of the present trend of using platinum in jewelry is indicated.

The growing importance of the secondary metal industry is shown graphically and briefly discussed, leading to an emphasis of the need for encouragement of scientific research to increase metal recovery. The United States is favored above most nations in being largely self-contained with respect to original sources of economic metals, yet it has no source for tin and platinum and inadequate sources for manganese, chromium and other less common metals essential to present day steels.

The work of a joint commission of the American Institute of Mining and Metallurgical Engineers and the Mining and Metallurgical Society of America is outlined, giving briefly their recommendations for international control of minerals.

The paper is concluded by emphasis of the importance of secondary metal recovery to national existence in times of stress when the nation may be thrown entirely upon its own resources. The conclusion also makes an appeal for the consideration of international conventions on economic metal exchanges and suggests that competent technical men be taken more into political councils in the treatment of a problem of this kind.

Tone Reproduction in the "Halftone" Photo-Engraving Process,[4] by Herbert E. Ives. The "halftone" photo-engraving process was invented, and its technique developed, prior to the days of what is commonly called "photographic sensitometry." The necessary conditions and the appropriate operations for securing "highlight" and "shadow detail", were found by empirical studies guided by the appearance of the result, as appraised by the unaided eye. No comprehensive sensitometric

[4] J. O. S. A. & R. S. I., March, 1926, p. 537.

study of the halftone reproduction process appears to have been made, at any rate none have been published. The work described is a rough survey of the problem, but, due largely to the use of accurate photometric measurements, and the correlation of these measurements with other sensitometric data, rather decisive conclusions have been possible as to the essential characteristics of the process in question, and on the procedures necessary for its complete success.

Frequency Measurements with the Cathode Ray Oscillographs,[5] by Frederick J. Rasmussen. The cathode ray oscillograph frequency measurement circuit described, differs from previous circuits in the use of by-pass condensers and plate leaks which permit the connection of the oscillograph to a-c, circuits having large d-c, components and which permit the use of biasing controls for shifting the position of patterns on the screen.

Reference oscillators are used in conjunction with the frequency standards. They are of a type chosen for their high stability.

The well-known properties of Lissajous' figures are reviewed briefly and then are developed more fully for the cases in which only one term of their ratios may be determined from the oscillographic pattern. Following a general discussion of the accuracy of syntonization, there is discussed a detailed method of calibrating oscillators. The patterns used may be interpreted from one term of their ratio.

Several special circuits are described for use in frequency measurement work with the cathode ray oscillograph.

The methods and apparatus described are suitable not only for the technical measurements of a development and research nature but are equally adaptable for routine commercial work. The advantages which particularly commend themselves are the rapidity with which such work may be done and the ease with which the average man can learn the work.

[5] Presented before the A. I. E. E., New York, N. Y., Nov., 1926.

Radio Broadcast Coverage of City Areas,[6] by Lloyd Espenschied. Radio broadcasting involves a system of electrical distribution in which dependent relations exist between the transmitting station, the transmitting medium and the receiving station.

The attenuation and fading which attend the spreading out of broadcast waves are considered. The attenuation of overland transmission is shown to be, on the whole, very high and to vary over a wide range depending upon the terrain which is traversed. The distance at which the fading of signals occurs is found to be that at which the normal directly transmitted waves have become greatly attenuated and to depend upon the terrain traversed.

A field strength contour map is given of the measured distribution of waves broadcast by station WEAF over the New York metropolitan area. A rough correlation is given between measured field strengths and the serviceability of the reception in yielding high grade reproduction. The range of a station as estimated in terms of year-round reliability is found to be relatively small. It becomes clear that the present radio broadcasting art is upon too low a power level and that higher powered stations are required if reliable year-round reception is to be had at distances as short even as 30 to 50 miles from the transmitting station.

The question of the preferred location of a transmitting station with respect to a city area is considered. It is shown that an antenna located upon a tall building may radiate poorly at certain wave-lengths and well at others. Surveys are presented of the distribution effected by an experimental transmitter station located in each of several suburban points. The locations are compared upon the basis of the "coverage" of receiving sets which they effect.

Finally, there is considered the relation which exists in respect to interference between a plurality of

[6] Bell System Technical Journal, Jan., 1927.

broadcast transmitting stations operating in the same service area. The importance of high selectivity in receiving sets is emphasized and there is given the measured selectivity characteristics for samples of a number of receiving sets.

A Shielded Bridge for Inductive Impedance Measurements at Speech and Carrier Frequencies,[7] by W. J. Shackelton. A shielded, a-c., inductance bridge adapted to the measurement of inductive impedances at frequencies up to 50,000 cycles is described. The bridge comprises a balancing unit and associated standards of inductance and resistance. The balancing unit has resistance ratio arms specially constructed to meet the requirements imposed by the above frequency range. The reference standard makes use of inductance coils of a new type, their cores being of magnetic instead of non-magnetic material as is usually the case. The use of such cores results in coils that are smaller and hence better adapted to assembly in a multiple shielded standard.

The bridge is completely shielded so as to eliminate, to a high degree, errors due to parasitic capacitance currents. The shielding is also arranged so as to permit the correct measurement of either "grounded" or "balanced-to-ground" impedances. A series of diagrams is shown for the purpose of indicating the function of each part of the shielding system.

Equations expressing the errors resulting from any small residual capacitance unbalances in the resultant bridge network are given and calculations made of the balances required for the desired degree of measurement precision. Test data are presented illustrating a method of experimentally checking the residual shunt and series balances from which it is concluded that the bridge is capable of comparing two equal inductive impedances of large phase angle with an accuracy at the maximum frequency of 0.02 per cent for inductance and 1.0 per cent for resistance.

[7] Bell System Technical Journal, Jan., 1927.

The Location of Opens in Toll Telephone Cables,[8] by P. G. Edwards and H. W. Herrington. Improved methods have recently been developed for the location of open conductors in toll cables, the discussion of these being prefaced by a review of older practices.

This improved open location method and equipment are so accurate that in practically all cases a fault in a 60-mile length of cable may be located within a maximum variation of plus or minus one-half the length of a cable section (the length of the section being about 750 feet), and therefore, enables one to select, prior to the opening of the cable one or the other of the two splices between which the fault lies. This degree of accuracy is very desirable for practical reasons.

In the present developments, the line characteristics are considered. The accuracies of calculated locations, assuming no errors in measurements, are compared for different lengths of lines. The impedance bridge circuit is treated to bring out the method of obtaining a balance. The effects of several frequencies of testing potential are analyzed. The probable errors and inaccuracies of measurement which would interfere with the correct location of faults, are classified and methods for their correction are developed. The accuracy of the method and the sensitivity of the apparatus are given.

Dynamical Study of the Vowel Sounds,[9] by Irving B. Crandall. Comparative studies based on oscillographic records of the principal characteristics of vowel, semivowel, and consonant sounds, have contributed much to an understanding of the mechanism of speech. Analyses of the frequency spectra of vowels show almost invariably two principal resonance peaks which fact is suggestive of a double resonator to produce them.

The present paper is concerned with the mechanism of the double resonator system and a mathematical treatment thereof. Based on the volume, shape and coupling

[8] Bell System Technical Journal, Jan., 1927.
[9] Bell System Technical Journal, Jan., 1927.

of the resonating chambers, some models of cardboard tube and placticene were made with which some experimental tests in the production of vowels were carried out. The best success was had with the sound ä (father) while fair results were obtained with the sound ō, ă and ĕ.

Electromagnetic theory and the Foundations of Electric Circuit Theory,[10] by John R. Carson. The familiar equations which are used to solve for the currents and charges in linear networks summarize the inductive analysis of countless observations made upon such networks. Having been arrived at by inductive methods, these familiar equations of Ohm, Faraday and Kirchhoff are substantially independent of the more general electromagnetic theory of Maxwell and Lorentz. The present paper examines the foundation of electric circuit theory from the standpoint of the fundamental equations of electromagnetic theory and a derivation of the former from the latter is made, in the course of which the assumptions, approximations and restrictions tacitly involved in the equations of circuit theory are explicitly stated. The treatment is sufficiently extended as to show how the familiar equation for the simple oscillating circuit and the so-called telegraph equation can be deduced from the Maxwell-Lorentz statement of electromagnetic theory.

Toll Switchboard No. 3,[11] by J. Davidson. This paper describes a new type of toll switchboard which has recently been designed for toll centers where there is sufficient toll traffic to require separate toll and local switchboards. This switchboard is more adaptable than previous types of boards to machine switching and other methods of operation now under consideration. The signaling equipment which was previously located in the cord circuits has been transferred to the line and trunk circuits and use has been made to a considerable extent of common positional equipment. It effects equipment

[10] Bell System Technical Journal, Jan., 1927.

[11] Bell System Technical Journal, Jan., 1927.

economies due to a reduction of equipment, gives improved maintenance arrangement, improves service to the subscriber and is more readily adapted to modifications required by new operating methods.

Contemporary Advances in Physics,[12] by K. K. Darrow. This paper recounts the leading phenomena and relationships of radioactivity and the interpretation of the radioactive process in atomic theory is discussed.

[12] Bell System Technical Journal, Jan., 1927.

Notes on Recent Occurrences

AWARD OF JOHN SCOTT MEDAL

THE Board of City Trusts of Philadelphia have announced the awarding of the John Scott Medal to G. W. Elmen of the Bell Telephone Laboratories. The medal and its accompanying honorarium were founded in 1816 by John Scott of Edinburgh.

Mr. Elmen is the inventor of permalloy, a nickel iron alloy of remarkable magnetic properties. This metal finds use in transformer cores, in certain telephone receivers, and most strikingly in the continuous loading of submarine telegraph cables for high speed service.

Recipients of the John Scott Medal have been inventors of outstanding achievement.

BELL SYSTEM WINS "SESQUI" GRAND PRIZE

> "In recognition of the epoch-making development and the continual improvement of a nation-wide means of direct communication unified by the Bell System."

THIS is the citation that accompanies the grand prize award to the American Telephone and Telegraph Company and Associated Companies, as recently announced by the International Jury of Awards of the Sesquicentennial International Exposition.

Thus history repeats itself and the city which saw the first award of merit to the infant invention of Bell is the scene, fifty years later, of another signal honor for the telephone.

The exhibit of the System upon which the award was based consisted of a building erected by the American Company in the Palace of Liberal Arts No. 1. In the entrance was displayed a duplicate of the primitive telephone apparatus exhibited by Bell at the Centennial Exposition in 1876. It was the original of this instrument that received the first award of merit given to the telephone by a Board of Judges including the leading scientists of Great Britain and the United States, Sir

William Thompson and Prof. Joseph Henry. The former prophesied in making his report on awards, "We may confidently expect that Mr. Bell will give us a means of making the voice and spoken words audible through the electric wire to an ear hundreds of miles distant. Suggesting the fulfillment of this prophesy was the display at the exhibit of a modern central office with miniature operators at their positions and other details perfectly reproduced in wood and clay, representing the system of today that inter-connects over 17 million telephones.

The Telephone Theatre which was housed in the American Company's exhibit with a seating capacity of 210 operated for 23 weeks during the Sesquicentennial Exposition, showing motion pictures describing 50 years of telephone progress to a total of over 165,000 visitors.

GENERAL COMMERCIAL SUPERVISORS' CONFERENCE

A CONFERENCE of General Commercial Supervisors in the Bell System was held in New York City, December 6th to 11th, inclusive. While business office operations and management, as to which the Commercial Supervisors have staff or advisory responsibilities, have occupied an important place in commercial conferences in the past, the recent meeting was the first occasion on which the Commercial Supervisors as a group have met to discuss this and other phases of their mutual problems.

The key-note of the conference was improvement in the quality of business office service with especial attention to the rendering of a more personal service to customers. It appears that the accomplishment of this objective will lie largely in more effective administration including still greater emphasis on the training and development of personnel.

Each of the topics was developed through planned discussion by Commercial Supervisors who gave the

experiences and performance results of their companies. This procedure met with a hearty response from the conferees and appeared instrumental in sustaining a high degree of interest in the topics and centering discussion around actual experience.

The importance of organized planning in commercial work was developed. Experience has shown that a program appropriate to local requirements aids in obtaining a well balanced commercial job, minimizes the effort required in planning, facilitates administration and aids in the development of the personnel.

Large city organization problems were discussed. The importance of capable and adequately trained personnel occupied an important place and the necessity for careful and planned selection together with appropriate training means, were developed. Various types of training activities were reviewed; experience appeared to indicate that other means are helpful supplements to, but not substitutes for, careful guidance by capable supervisors.

While conditions during and immediately following the war made it necessary for the companies generally to forego active sales effort, progress in adding plant facilities has reached the point during the past several years where increasing sales activities have been warranted. The controlling incentive of all sales effort was stated to be improvement in service to customers and in net earnings. Emphasis was placed on the desirability of assisting customers in obtaining service of such type and amount as will best meet their requirements. Extensive illustrations of the results secured from various classes of sales activities were presented and it was pointed out that the effective planning of sales activities requires close cooperation and coordination between the various departments. Many examples were given illustrating the very substantial contributions made by the employees of other departments in carrying on the sales activities.

The progress in developing and using, in training work and in improving performance, significant information with regard to the quality of business office work was reviewed, special consideration being given to the "observing" of contacts with customers—telephone, counter and mail. The opportunities for effective use of information concerning the volumes of different classes of work in connection with the planning of force requirements and work assignments were developed; this appears to be helpful in obtaining not only better production results but improvement in the quality of the service. The experiences of the various companies in the use of results information to improve operations developed that, not only is it important to have adequate information, but its significance must be fully understood and there must be organized effort to utilize it to its full value. The organization, methods of working of the Commercial Supervisors' office and its relation to the line organization were given careful consideration.

The conference was addressed by President Gifford, Vice President Gherardi and a number of other officials of the American Company.

It was evident from the data presented that there have been definite improvements during the past year in both the quality and efficiency of business office performance. It was the general opinion of the conferees that the discussions had been of considerable value in pointing out opportunities for, and developing means of, further substantial improvements in the service to customers.

THE COUNSEL'S CONFERENCE

NEARLY all the general counsel for the Associated Companies attended the counsel's conference held on December 7th, 8th and 9th at 195 Broadway. Except for Mr. Gifford's remarks opening the conference and for an address by Mr. Guernsey on the 8th, the meetings were devoted to general discussion of various legal prob-

lems of current interest. The conference closed on December 9th with a dinner given to the conferees by Mr. Bracelen at the University Club.

CHICAGO-ST. LOUIS CABLE OPENED

JOINT ceremonies in New York, Chicago and St. Louis on December 15 inaugurated the newly-completed long distance cable link between Chicago and St. Louis, insuring for the future the best possible storm-protection for communication through from New York to St. Louis as well as between intermediate points.

From the New York end, President Gifford of the American Telephone and Telegraph Company and President McCulloh of the New York Telephone Company exchanged greetings with President Nims of the Southwestern Bell Telephone Company and President Abbott of the Illinois Bell Telephone Company in their respective headquarters. Mr. James Brown, Chairman of the executive committee of the Chamber of Commerce of the State of New York, opened the commercial service with congratulations to the heads of similar bodies in St. Louis and Chicago.

The new link, 344 miles in length, requiring two years to construct and an expenditure of $7,000,000, is an extension of the New York-Chicago long distance cable completed in August, 1925. It will provide more than 250 telephone circuits, and more than 500 telegraph messages can also be sent simultaneously, making it the equivalent of ten heavily loaded pole lines of open wire.

Organization Changes

American Telephone and Telegraph Company

Arthur W. Page elected a Vice-President

A.B., Harvard, 1905; editorial work, Doubleday, Page & Co., 1905; editor, *The World's Work*, 1913–1926; Vice-President, American Telephone and Telegraph Company, January 1, 1927.

James D. Ellsworth appointed Assistant to President

Entered employ of Bell System, 1907, as special agent, later becoming Publicity Manager; Assistant Vice-President, American Telephone and Telegraph Company, 1924; Assistant to President, January 1, 1927.